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THE ECONOMICS OF SMALL-SCALE SEAWEED PRODUCTION IN THE SOUTH CHINA SEA REGION

by

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PREPARATION OF THIS DOCUMENT

The relatively low unit prices paid to the producers of the raw material from which seaweed products are made lends importance to the overall economics of seaweed production. The present document summarizes the limited information available for the South East Asia region. It has been prepared for a Workshop on the Production and Utilization of Commercial Seaweeds to be held in Qingdao, China, in 1937, under the FAO Technical Cooperation Programme.

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ABSTRACT

This paper reviews available economic data and previous publications on the four major seaweed species cultivated in the South China Sea region. These are the red seaweeds *Eucheuma*, *Gracilaria* and *Porphyra* and, to a much lesser extent, the green seaweed *Caulerpa*.

Available data indicate good profitability on small farms of one hectare or less in size. Particularly in the case of *Eucheuma* farming, the industry has successfully attracted families out of full-time fishing. Prices paid by oligopsonistic middlemen/processors have been highly volatile, however, partly in response to unpredictable supply from responsive farmers.

Available economic data on seaweed farming is very scanty and fails to address key issues with respect to yield and profit variability among farms. Because of these data inadequacies, the future of small farms in the seaweed industry of the South China Sea region remains a matter of conjecture.

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1. INTRODUCTION

Scientific seaweed farming is a recent endeavour, dating only from the 1940s in Japan and China, the two countries currently with the greatest volumes of annual seaweed production (Doty, 1984). China is now the world's largest seaweed producer (annual production of approximately 275 000 t dry weight, or 40% of the world total) and much of this is a cultured crop (Tseng, 1980). The culture of seaweed in the South China Sea region has developed even more recently and only then after increased world market demand for the products derived from seaweed (Tables 1 and 2) had contributed to the overexploitation of wild stocks. China's production, in contrast, is primarily for domestic markets and human consumption.

This distinction between domestic and international market orientation is important because the two outlets bring to bear different sets of economic conditions and marketing structure that influence prices and hence profits received by seaweed farmers. While Chinese domestic prices are thought to have remained somewhat stable for their major products (*Laminaria, Gracilaria, Porphyra*), prices received by farmers in the Philippines for exported *Eucheuma*, for example, have been highly volatile, especially after the initial establishment of the industry there in the 1970s. Outlets are, of course, not necessarily a matter of producer choice in that potential markets are determined by the characteristics of and available uses for the fresh and processed seaweed products. Nevertheless, recent experience with Asian seaweed clearly indicates the responsiveness of producers to increased and diversified demand whether the product in question is *Gracilaria* for use as an abalone feed (as in Taiwan, Province of China) or *Eucheuma* for carrageenan extraction (as in the Philippines). In fact it is this rapid response of producers to economic opportunities and the resulting overproduction, rather than demand conditions alone, which explains the wide fluctuations in Philippine *Eucheuma* prices. In all Southeast Asian countries the combined effects of demand and supply will determine prices received by producers; there is no government control over seaweed prices in any Southeast Asian country at the moment, though some markets are controlled by a very small number of price-setting buyers.

World seaweed demand is reasonably stable, growing at about 10% per year (Doty, n.d.). The international demand for seaweeds has grown much more rapidly, however, world trade in seaweed and seaweed products was valued US$ 50 million in 1970 and five times that by 1980 (ITC, 1981). A discussion of the reasons for this expansion - increased raw materials and energy costs for chemical industry products of which seaweeds are a part or a substitute - can be found in the ITC publication.

Reliable data on worldwide production of seaweeds are not available (Chua, 1986, points up weaknesses in FAO estimates). Of world seaweed production, virtually all cultured seaweed comes from Asia; the bulk comes from Japan, Korea, China and India. The only major Southeast Asian producers of cultured seaweed are the Southern Provinces of China, the Philippines and to a lesser extent Indonesia. Unfortunately, useful economic data on these seaweed culture industries are even more difficult to locate than are the production data. This data shortage is not a problem unique to seaweed, however, as Asian aquaculture is generally poorly monitored despite its rapid growth and economic importance to the region.

Economic data that are available concentrate upon: (1) financial aspects of seaweed production on small farms (areas of approximately one hectare are often used for hypothetical costs and earnings projections), or to a much lesser extent, (2) prices received by farmers and fob prices for the semi-processed (dried) seaweeds. The problem with much of these data is not only that they are often out-of-date, but also that they are generally based upon data gathered from only a small number of farms and hence may not be representative of the industry as a whole.

The purpose of this paper is to examine the economics of small-scale seaweed culture in the South China Sea region (see Figure 1). It is not intended to examine the economics of marketing and processing for the various colloids, agar, alginates and carrageenan which can be derived from seaweeds. Given the secrecy that surrounds the handful of processors that operate in the region at present, this would be an exceedingly difficult task in any case. Rather this paper will report on and compare the various production cost and selling price data that are available and then proceed to a discussion of the economic

issues surrounding management decision making of small-scale seaweed farmers. From this discussion, concluding observations will be made regarding the likely future for the major cultured seaweed species of the South China Sea region.

2. SOUTH CHINA SEA SEAWEED PRODUCTION

As noted in Figure 1, the South China Sea region is considered to include those countries bordering on the sea, including, clockwise from the East: the Philippines, Malaysia (Sabah and Sarawak), Indonesia, Malaysia (Peninsular), Thailand, Kampuchea, Viet Nam, China (Guangdong and Taiwan Province). The seaweed grown in the South China Sea region can be considered tropical seaweed. Major seaweed producing areas exist northward along the coast of China in Fujian Province, but these are not included here as they are neither on the South China Sea region nor in the tropics. No economic information on the species grown there (*Porphyra*) is available to this author in any case, although several publications in Chinese are potentially useful if translated or otherwise accessed.

Table 1

Seaweed as raw material: their use and exploitation

Product	Raw material: seaweed groups/ principal genera utilized			Estimated global harvest 1980 (tons dry weight)
Seaweed colloids:				270 000
Agar	**Red seaweeds:**	Acanthopeltis Gelidiella Gelidium	Gracilaria Pterocladia	36 000
Alginate	**Brown seaweeds:**			190 000[a/]
	Ascophyllum Dirvillea Ecklonia	Fucus Laminaria Macrocystis	Nereocystis Sargassum Turbinaria	
Carrageenan	**Red seaweed:**			40 000
	Chondrus Eucheuma	Gigartina Hypnea	Iridaea Phyllophora	
Furcellaran	**Red seaweed:**	Furcellaria		4 000
Food for direct human consumption	**Red seaweed:**	Porphyra		385 000
	Brown seaweed:	Hizikia Laminaria	Undaria	
	Green seaweed:	Caulerpa Enteromorpha	Ulva	
Fertilizer & animal feed	**Brown seaweed** such as those listed for alginate, but most commonly:			
	Ascophyllum	Sargassum		

a/ Including about 90 000 t of dried seaweed used in China in alginate manufacture marketed entirely within the country

Source: International Trade Centre UNCTAD/GATT and industry sources as reported in ADB/FAO (1983)

Table 2

Species of seaweeds utilized in Asia

	Level of utilization	Uses	Source	
			Wild	Cultured
Red algae				
Acanthophora	++	Human food, carrageenan	x	x
Asparagopsis	+	Human food, fodder	x	
Bostrychia	+	Human food	x	
Catenella	+	Human food	x	
Corallopsis	+	Human food, agar	x	
Digenea	++	Medicinal, agar	x	
Eucheuma	+++	Carrageenan, human food	x	x
Gelidiella	+++	Agar	x	
Gelidiopsis	+	Agar, human food	x	
Gelidium	+++	Funorin, agar, human food	x	
Gloiopeltis	+	Agar, human food, medicinal	x	
Gracilaria	+++	Funorin, human food	x	x
Grateloupea	+	Human food	x	
Griffithsia	+	Human food	x	
Gymnogungrus	+	Carrageenan, human food, medicinal	x	
Halymenia	+	Human food	x	
Hypnea	+++	Human food, agar	x	
Laurencia	+	Human food	x	
Liagora	+	Human food	x	
Porphyra	+++	Human food	x	x
Scinaia	+	Human food	x	
Brown algae				
Chnoospora	+	Human food	x	
Hydroclathrus	++	Human food, fodder, manure alginate, medicinal	x	
Padina	+	Human food	x	
Sargassum	+++	Fodder, alginate, manure potassium chloride, iodine	x	
Turbinaria	+	Human food, alginate	x	
Green algae				
Caulerpa	+++	Human food	x	x
Chaetomorpha	++	Fish food	x	x
Cladophora	++	Fish food	x	x
Codium	+++	Human food	x	
Enteromorpha	+++	Human food, fish food	x	x
Halimeda	+	Fodder	x	
Monostroma	+	Human food	x	
Ulva	+	Human food, animal feed, manure, medicinal	x	x

+++ Extensively utilized

++ Fairly utilized

+ Less utilized

Source: Rabanal and Trono (1983)

For purposes of this paper, a distinction is made between cultured seaweeds and those collected from the wild. Included in this latter category are those which accumulate essentially naturally with subsequent manual gathering. *Porphyra*, for example, has been collected in the Northern Philippines by placing poles with split ends closely together along the shore; the algae are then collected 4-6 months later by hand at low tide (Michanek, 1975). Such systems of natural accumulation are distinct from those where initial seeding or transplanting is done manually and the growing period carefully supervised. It is these more managed systems that are the subject of this paper.

Only three major species (the red seaweeds *Eucheuma*, *Gracilaria* and *Porphyra*) and a fourth of minor importance (the green seaweed *Caulerpa*) meet this management criteria and can thus be truly classified as *cultured* seaweeds. Even for these seaweeds, true culture practices are not widespread throughout the South China Sea region (Table 3), though there has been considerable growth in the industry over the past 20 years.

Figure 1 South China Sea Region

For these four species, only two basic production systems are practised, though there is much variation in methods within these systems. These two basic systems are (1) shallow water culture on monofilament line sor nets and (2) culture in brackishwater ponds. These methods, and their improvements over time have been described in detail in numerous technical papers (e.g., Doty, 1973, 1977, 1984; Rabanal and Trono, 1983; Trono and Ganzon-Forter, 1981, 1985) and elsewhere in this volume; (Doty *et al.*, Eds...) therefore no great amount of technical detail need be provided here.

3. SEAWEED PRODUCTION ECONOMICS

3.1 *Eucheuma* culture

Eucheuma has been gathered from the wild for centuries in Southeast Asia. Initially used for human consumption - it still is in some lacations - *Eucheuma* is now grown primarily for the kappa and iota carrageenan extracts which can be derived from *E. cottonii* and *E. spinosum* respectively. Eight tons of wet seaweed yields approximately one ton

Table 3

Status of cultured seaweed production in South China Sea Region[a/]

	Eucheuma	*Gracilaria*	*Caulerpa*	*Porphyra*
BRUNEI	none	none	none	none
MALAYSIA				
Sabah	experimental	none	none	none
Sarawak	none	none	none	none
Peninsular	none	experimental	none	none
PHILIPPINES	considerable	some	some	none
THAILAND	none	none	none	none
SINGAPORE	none	some	none	none
VIET NAM	none	some	none	none
KAMPUCHEA	none	none	none	none
CHINA				
Hainan (Guangdong)	some	considerable	none	considerable
Taiwan Province	experimental	considerable	none	some
INDONESIA	some	some	some	none

a/ Cultured seaweed only; does not include seaweed gathered from the wild or collected naturally from simple bamboo stakes (e.g., *Porphyra* in northern Philippines)

dried, which in turn yields approximately 300 kg of carrageenan. Experimental work on *Eucheuma* culture began in the Philippines approximately two decades ago; currently the Philippines produces something on the order of 20 000-25 000 t dried *Eucheuma* each year, or approximately 95% of the world's total cultured *Eucheuma* and half of the world's carrageenan comes from Philippine seaweeds (ADB/FAO, 1983). Culture of *Eucheuma* is also undertaken in Indonesia (Hollenbeck, 1982) and Southern China (Liu and Zhuang, 1984), though on a much smaller scale than in the Philippines. *Eucheuma serra* has been suggested for culture in Taiwan (Province of China) (Tseng, 1984). Fiji and Kiribati in the South Pacific have also initiated *Eucheuma* culture (Russell, 1982) and the Kiribati work has been particularly successful with 40 family farms now in production (Why, 1985). Malaysian *Eucheuma* culture is still at the experimental stage (Madhu, 1983). The key to Philippine success appears to have been the willingness of large numbers of fishermen to change their occupations or at least to become part-time seaweed farmers, coupled with the sustained presence of corporate buyers for the dried seaweed. Indonesian seaweed farms, in contrast, have suffered from poor management and an undeveloped marketing infrastructure.

In the Philippines, seaweed culture has been most successful in the Tawi-Tawi region in the southwest Sulu archipelago near the border with Sabah. Large areas of shallow reef and sand in this area are suitable for *Eucheuma* culture. Although the area is a relatively rich fishing area, it is so far removed from major markets that incomes derived from fishing are low (Nimmo, 1972), just as they are in many other parts of the country where the problem is not so much isolation from markets as it is declining catch brought about by extreme competition and overfishing.

The second major seaweed growing area in the Philippines, north of Bohol island, fits the latter characterization; here, too, a large shallow reef area, the Danajon Bank, is suitable for *Eucheuma* farming. In both locations, as is true of many of Philippine fishing communities (Smith, Puzon and Vidal-Libuano, 1980), fishermen and their families were enthusiastic to become involved in an activity which gave promise of increasing their

income levels. There has been little hesitation amongst fishermen, it seems, to enter this new occupation, explainable in part by the relatively modest initial capital requirements for seaweed farming and in part by the progressive family-oriented entrepreneurial system that prevails in much of the Philippines. By most standards, the *Eucheuma* seaweed farming industry has been remarkably successful in involving small-scale family-run production units in a relatively short period of time. By the mid-1980s, annual Philippine production of cultured seaweed approached 20 000 t of dried *Eucheuma*.

As has been the case with other fishing developments in other parts of Asia (e.g., the development of fishing community cooperatives in Japan) the rapid rate of expansion of the seaweed industry in the Philippines can be traced to the dedicated efforts of a small number of individuals, such as Mr Vicente Alvarez and Dr Gavino Trono in the Philippines and Dr Maxwell Doty based in Hawaii. Their colleagues in government, universities and particularly among the private sector buyers - of whom there are but a few - also lent considerable support. These efforts were aided considerably by favourable economic conditions, including the growing world demand for carrageenans, the overfishing of wild *Eucheuma* stocks in both the Philippines and Indonesia, and the rapidly increasing costs of energy in the early 1970s which had the potential to make Southeast Asian products (such as processed seaweeds) highly competitive with those produced in the industrialized countries of North America and Europe (ADB/FAO, 1983). The persistence of individuals such as Mr Alvarez, Dr Doty, Dr Trono and others in the Philippines has resulted in Philippine prominence; only now are other countries such as Indonesia and Malaysia beginning to expand their production of cultured *Eucheuma*.

Despite the importance of this industry to the Philippines (US$ 20 million foreign exchange generated in 1985) (NCSO, 1986), ranking seaweed in third place behind total shrimp and tuna exports of US$ 116 million, economic analysis of production and marketing arrangements have been somewhat *ad hoc* and sketchy. The remoteness of the Tawi-Tawi region and until recently the danger to outsiders working there has something to do with this; more important is the fact that the marketing and processing sector is concentrated in only a small number of companies which are willing to share only partial information on economic aspects of their operation.

Economic data available are of two types: first are the various hypothetical projections based on experimental data made by government, university and corporate biologists who work on various aspects of *Eucheuma* biology and farming; second are a small number of government and university surveys of practising seaweed farmers. The hypothetical projects consistently show remarkable possible profits in the order of 5-10 times what would be obtained from fishing. The surveys indicate that actual family-run farms are profitable, but earning considerably less than what the hypothetical projections would predict. The two major differences between the respective data sets are in (1) the annual production estimated and achieved, and (2) the calculating of costs, particularly operating costs. These differences are of more than academic interest because as pointed out by Doty (in press) reasonable projections of productivity and financial return are essential to convince governments in non-producing areas of the value of the necessary 2-3 year experimental period in new locations.

As the following discussion and accompanying tables will hopefully show, it is important that the hypothetical projections based on experimental or corporate farming data be tempered by the analysis available from the surveys. The Doty manuscript referred to above is the first serious attempt to deal with the problem of extrapolation of production and profits from experimental or pilot scale work, though it too does not draw sufficiently upon the few available economic surveys. Its real contribution is more in the area of proposing a methodology for dealing with the environmental and economic variables (e.g., tides, turbidity, planting density, seasonality, farm management and farmer share of the export price) that influence farming success.

Comparisons among these various hypothetical data sets is difficult because of different cost calculations, the time lapse between estimates and the Philippine currency (peso) fluctuations (devaluation) which accelerated in 1981. Parker (1974) refers to family-run 0.25 ha "modules" and estimates annual production of 3.3 t and annual gross income of P 5 000 per "module". He reports *E. striatum* production of 13 $t/ha/yr^{-1}$ (dry weight) from an experimental site in Sulu and cites an estimate by Doty of 30 $t/ha/yr^{-1}$ (presumably for *E. cottonii*, the commonly used term nowadays for *E. striatum*). The most important conclusion of Parker for small-scale seaweed farming is not so much the production data *per se*,

but his annual net income estimate of P 9 000 for a two-module (0.5 ha total) family farm, which at the time (1974) was six times the income of an agricultural worker earning the minimum wage.

A few years later, Deveau and Castle (1976) estimated potential net annual income from a *E. cottonii* family farm of P 10 250 (US$ 1 360) or more than 3 times the then prevailing average family income in the country. This estimate, as was Parker's assumes a family can reasonably manage a 0.5 ha farm. They estimated that such a farm could produce 9 t/yr as the equivalent of 18 t/ha/yr^{-1}.

By 1980, hypothetical projections had raised the potential (4 member) family farm size to one hectare but assumed that it would be more extensively farmed than experimental plots and the larger corporate farms, a few of which had entered the business during the 1970s. Two projections made in the early 1980s varied considerably, particularly in their estimates of expected production and costs, but were similar in their estimates of per unit production costs (both were for *E. spinosum*). These two projections are compared in Table 4.

Since the average production costs/kilogramme projected by these two studies are similar, critical factors in the profitability calculations are the accuracy of the projected production estimates and prevailing prices. Although neither of the above two studies state explicitly whether they are referring to extensive or intensive farms (determined by the number of seeds used per hectare) the average production cost data presented are in the same neighbourhood as those gathered by Smith and Pestaño-Smith (1980) during an actual 1979 survey of *E. spinosum* producers in the northern vicinity of Bohol on the Danajon bank (reef).

The results of this survey are shown in Tables 5-8. For extensively operated farms, costs of production (excluding family labour) was P 2.34/kg; for intensively operated farms it was P 1.93/kg (also excluding family labour). Most of the small farms were extensively (approx. 30 000 seed plants/ha) farmed. If one assumes, for the sake of comparison, that these family managed farms required one full time family worker in addition to the hired labour included in Tables 6 and 9, and that this family labourer could earn P 15-20/day in alternative occupations (e.g., fishing) then break-even costs of production would be P 3.14/kg for the extensively operated farm and P 2.25/kg for the intensively operated *E. spinosum* farm. In mid 1979, *E. spinosum* prices were P 4.60/kg; by January 1980, in response to tremendous production of 350 t in November 1979 (equal to the entire annual *E. spinosum* production of the country in 1978!), prices had fallen to only P 2.00/kg, just barely enough to cover the major operating costs (but not fixed costs) and to provide a small return to family labour. By November 1980, the price paid to farmers for *E. spinosum* had fallen to only P. 0.55/kg (Hollenbeck, 1983).

There is a clear difference in the Philippines, however, between production costs on these *E. spinosum* farms near Bohol numbering (approximately 100 farms currently) and the much more numerous *E. cottonii* farms in Tawi-Tawi (probably more than 3 000 farms). Santillan (1986) reports that most of the approximately 2 500 ha under production in the Tawi-Tawi and Sulu areas are not licensed and therefore "illegally" occupied. Two surveys of producers have been conducted in this Mindanao area; the first in 1978/79 by Guerrero, Hernandez and Fabia (1980) and the second in 1981 by Hollenbeck (1983). Unfortunately the Hollenbeck farm survey remains incomplete, disrupted by the deteriorating peace and order conditions in Mindanao in the early 1980s. The Guerrero study, however, covered 91 producers (approximately 5% of all seaweed producers in Mindanao at that time) who operated seaweed farms ranging in size from less than 0.25 ha to over 1 ha. Guerrero considered any farm of 1 ha to be "large". (The licensing limit for an individually owned farm was also 1 ha.) The majority of farms were producing *E. cottonii* (95% of the total production of the 91 farms in 1978/79.

The data collected by Guerrero indicate some very clear differences between experimental farm projections made by Doty and colleagues in the early 1970s and actual farm yields as experienced by family-run farms in the late 1970s. First of all, production levels are considerably lower than experimental projections, ranging from 2.4-7.6 t/ha/yr^{-1} depending upon farm size (Table 9). But at the same time, average investment costs and annual

Table 4

Two estimates of per unit production cost (*E. spinosum*) from family farms (1 ha)

	1980[a/]	1981[b/]
Projected production (t/yr)	8	22.5
Initial capital costs[c/] (pesos)	11 000	14 400
Operating costs[d/]	19 845	35 847
Average production cost/kg[e/] (pesos)	2.71	2.36

a/ Lim and Porse (1980)
b/ Trono and Ganzon-Forter (1981)
c/ Covers farm house, boats, engine, stakes and monoline in case of Lim and Porse; only farmhouse, boats and engine in case of Trono and Ganzon-Forter
d/ Includes depreciation of capital items at 20% per year (5 year life) and family and hired labour
e/ In 1980, P 7.35 = US$ 1.00; in 1981, P 7.65 = US$ 1.00

Table 5

Initial investment costs and annual depreciation for a 1 ha *Eucheuma spinosum* farm, Bohol, Philippines in 1979 (extensively farmed)[a/]

Investment items	Cost (P)	Life (years)	Annual depreciation (P)
1 bamboo and nipa farmhouse	7 500	10	750
1 motorized banca[b/]	5 000	5	1 000
1 dugout	200	5	40
15 kg monoline at P 35	525	10	53
1 200 stakes at P 0.25	300	1	300
Hand tools[c/]	230	10	23
6 baskets at P 25	150	6 mos.	300
Lease (bond)[d/]	1 000	-	-
Total	14 905		2 466

a/ Approximately 30% of area is used. Cost data is based on December 1979 prices (P 7.32 = US$ 1.00)
b/ Equipped with 16 hp Briggs and Stratton gasoline engine
c/ Includes one crowbar and 3 sledge hammers for driving stakes
d/ The P 1 000 bond required to secure the lease from the Bureau of Fisheries and Aquatic Resources (BFAR) must be deposited in the local Rural Bank, and can be forfeited if the farm area is not made productive

operating costs were lower also (Tables 10, 11), thus offsetting the profitability impact of lower yields. At the time of the Guerrero survey, these *E. cottonii* farms, especially those in the 0.5-1.0 ha range were quite profitable. Note in Table 11 that Guerrero imputed costs for family labour; break-even costs, including this item, ranged from P 0.39-2.14/kg, and averaged only P 0.56/kg. Even the smallest farms, with average production costs more than 5 times as high as the largest farms, were still profitable at prices then prevailing which averaged P 1.62/kg for *E. cottonii* and P 4.07/kg for *E. spinosum*.

Table 6

Annual production costs (excluding labour) for an extensively farmed 1 ha *Eucheuma spinosum* farm in 1979 (Hingotanan, Bohol, Philippines)

	Subtotals (P)	Totals (P)
Cost of goods sold		
30 000 seed plants (3 000 kg) at P 0.80/kg)		2 400
Operating costs		
Tie-ties 60 kg at P 15	900	
Labourers (1) at P 10/day	3 650	
Harvesting Labourers:		
56 mandays at P 10	560	
Food for labourer at P 5/day	2 105	
Maintenance of banca, engine and farmhouse[a/]	1 250	
Gasoline[b/]	5 408	13 873
Depreciation (see Table 5)		
Farmhouse	750	
Banca/dugouts	1 040	
Monoline	53	
Stakes	300	
Tools	23	
Baskets	300	2 466
Total annual production costs: (excluding family labour)		18 739
Production: 8 t dried *Eucheuma*		
Unit cost of production: P 2.34 kg		

a/ 10% of investment cost
b/ 2 round trips per week Hingotanan to farm. Each trip consumes 16 litres of gasoline at P 3.25 per litre

Since they were conducted within a year of each other, the Guerrero, Hernandez and Fabia and Smith and Pestaño-Smith survey data can be compared, although bearing in mind that the former is for *E. cottonii* farms and the latter for *E. spinosum* farms. The key differences are in investment and operating costs. The Bohol *E. spinosum* farms required considerably more substantial farm houses, located as they were far from the nearest island residences. Also, due to farm distance from shore, motorized boats (bancas) were necessary and fuel costs thus became a significant proportion of total operating costs. Tawi-Tawi *E. spinosum* farms in contrast were much smaller in scale, average, and required much lower capital investment and operating costs. Both were quite profitable at the time, given prices then prevailing.

A final hypothetical projection for *E. cottonii* farming has been made by Shemberg Marketing Corporation (SMC, 1985). Summarizing, this one hectare family run farm would require P 31 000 for fixed assets (boats and farm house), P 24 000 for initial seedlings, posts, monoline and nets, P 28 000 for annual maintenance costs (labour and gasoline) and would yield 16.5 t/ha/yr^{-1} of seaweeds which at the time could have been sold for P 4/kg, or P 66 000 (P 61 500 less transport costs to buying station). The SMC calculations of annual costs incorrectly calculate depreciation, but assuming 5-year life for most items as done by other studies, total annual costs/hectare can be recalculated as approximately P 40 000 or P 2.41/kg. Based on this cost data and an assumed price/kilogramme received of P 6,

Table 7

Initial investment costs and annual depreciation for a 1 ha *Eucheuma spinosum* farm (intensively farmed), in 1979, Bohol, Philippines[a/]

Investment items	Cost (P)	Life (years)	Annual depreciation (P)
1 bamboo and nipa farmhouse	10 000	10	1 000
1 motorized banca[b/]	5 000	5	1 000
Dugouts at P 200	400	5	80
50 kg of monoline at P 35/kg	1 750	10	175
4 000 stakes at P 0.25	1 000	1	1 000
Hand tools[c/]	230	10	23
20 baskets at P 25	500	6 mos.	1 000
Lease (bond)	1 000	-	-
Totals	19 880		4 278

a/ Cost data is based on December 1979 prices (P 7.32 = US$ 1.00)
b/ Equipped with a 16 hp Briggs and Stratton gasoline engine
c/ Includes one crowbar and 3 sledge hammers for driving stakes
d/ The P 1 000 bond required to secure the lease from the Bureau in the local branch of the Rural Bank, and can be forfeited if the farm area is not made productive

Santillan (1986) has calculated a 24% return on sales and a 35% return on investment. As with earlier hypothetical studies, the key questions are whether family-run farms can actually achieve the expected yields of 16.5 t/ha/yr^{-1} and what price they will receive for their product.

Since average seaweed prices over a number of years are available only from the 3 major buyers/processors - all based in Cebu, Central Visayas, calculation of the prices actually received by farmers must take into account the markups that occur between the farmer and the Cebu buyer. Also, any time series price information must be adjusted to account for inflation over the period.

One of the major Cebu traders maintains "buying stations" in both Bohol and Tawi-Tawi. The most used marketing channels for *E. cottonii* and *E. spinosum* are from farmer (F) to trader (T) to buying station (BS) to Cebu processor/exporter (PE).

F ----------> T ----------> BS ----------> PE

In 1986, seaweed delivered to buying stations in Tawi-Tawi receives approximately P 1.00/kg less than seaweed delivered directly to Cebu; P 0.40/kg less if delivered to Bohol buying stations. The markup between farmer---> trader---> buying station in Tawi-Tawi is a matter of conjecture, though may be higher than one would think (see next page comments on middlemen and cost of credit).

Average prices for *E. cottonii* and *E. spinosum* were collected recently from two of the three major buyers in Cebu, and are shown for the 1979-86 period in Figure 2. Also shown are 1978 prices collected earlier by Smith and Pestaño-Smith (1980). While prices for *E. cottonii* remained reasonably stable until 1983, *E. spinosum* prices have fluctuated widely, dropping rapidly in 1980 (lowest price reached in November that year was P 0.55/kg (Hollenbeck, 1983) due to overproduction in 1979 and then rising again in 1982 after an usually early May typhoon in 1981 destroyed most Bohol seaweed farms.

Table 8

Annual production costs (excluding labour) for an intensively farmed 1 ha *Eucheuma spinosum* farm in 1979 (Hingotanan, Bohol, Philippines)

	Subtotals (P)	Totals (P)
Cost of goods sold		
100 000 seed plants (10 000 kg) at P 0.80/kg		8 000
Operating costs		
Tie-ties 200 kg at P 15	3 000	
Labourers (3) at P 10/day	10 950	
Food for labourers at P 15/day	5 475	
Maintenance of banca, engine and farmhouse[a/]	1 510	
Gasoline[b/]	5 408	26 343
Depreciation (see Table 7)		
Farmhouse	1 000	
Banca/dugouts	1 080	
Monoline	175	
Stakes	1 000	
Tools	23	
Baskets	1 000	4 278
Total annual production costs: (excluding family labour)		38 621
Production: 20 t dried *Eucheuma*		
Unit cost of production: P 1.93/kg		

a/ 10% of investment cost
b/ 2 round trips per week Hingotanan to farm. Each trip consumes 16 litres of gasoline at P 3.25 per litre

Table 9

Average annual production and yield, 91 seaweed farms, Western Mindanao, 1978-79

Species	Average farm size			
	Small farms (0.27 ha)	Medium farms (0.52 ha)	Large farms (1.0 ha)	All farms (0.68 ha)
E. cottonii	593	2 445	7 090	4 049
E. spinosum	59	6	503	216
Total	652	2 451	7 593	4 265
Computed yield per hectare	2 415	4 713	7 593	6 272

Source: Guerrero, Hernandez and Fabia (1980)

Table 10

Average investment and fixed costs, 91 seaweed farms, Western Mindanao, 1978-79

Item	Size of farm (P)			Average all farms (P)
	Small	Medium	Large	
Investment costs				
Buildings[a/]	164	493	1 060	673
Tools/equipment				
Banca[b/]	1 238	1 098	1 280	1 194
Hammers/fliers	2	17	7	11
Bolo/scythe	15	28	19	22
Scale	7	-	11	5
Baskets	5	3	13	7
Sacks	2	4	7	5
Others[c/]	-	14	4	8
Construction materials				
Nylon net	211	388	547	425
Bamboo/mangrove stakes	414	330	499	412
Plastic twine/cord	80	108	143	118
Total				
Per farm	2 138	2 483	3 590	2 880
Per hectare	7 919	4 775	3 590	4 235
Other fixed costs				
Interest	257	298	431	346
Depreciation	416	426	624	505
Repairs and maintenance	58	97	181	134
Total				
Per farm	731	821	1 236	985
Per hectare	2 707	1 579	1 236	1 449

a/ Includes seaweed shelter and shortage
b/ Includes mototized and non-motorized
c/ Includes crowbar and knife

Source: Guerrero, Hernandez and Fabia (1980)

Table 11

Gross income, expenses and net income (pesos), 91 seaweed farms, Western Mindanao, 1978-79

Item	Size of farm (P)			Average all farms (P)
	Small	Medium	Large	
Income				
Seaweed sold	1 472	3 375	10 719	6 068
Total income				
Per farm	1 472	3 375	10 719	6 068
Per hectare	5 452	6 490	10 719	8 924
Per kilo	2.26	1.38	1.41	1.42
Expenses				
Cash				
Hired labour	---	a/	2	1
Repairs and maintenance	58	97	181	134
Seaweed stock	143	388	465	382
Sacks	12	11	21	15
Tying materials	95	68	107	88
Hired transportation	5	21	7	13
Fuel and oil	4	4	33	16
Lease fee	---	4	3	3
Municipal licence	---	1	12	5
Food (hired labour)	9	5	29	15
Non-cash				
Interest on investment	257	298	431	346
Depreciation	416	426	624	505
Labour (operator, family)	399	947	956	866
Total expenses				
Per farm	1 398	2 270	2 871	2 389
Per hectare	5 178	4 365	2 871	3 512
Per kilo	2.14	0.93	0.39	0.56
Net profit b/				
Per farm	74	1 105	7 848	3 679
Per hectare	274	2 125	7 848	5 412
Per kilo	0.12	0.45	1.02	0.84

a/ Less than P 0.50
b/ Prior to marketing cost

Source: Guerrero, Hernandez and Fabia (1980)

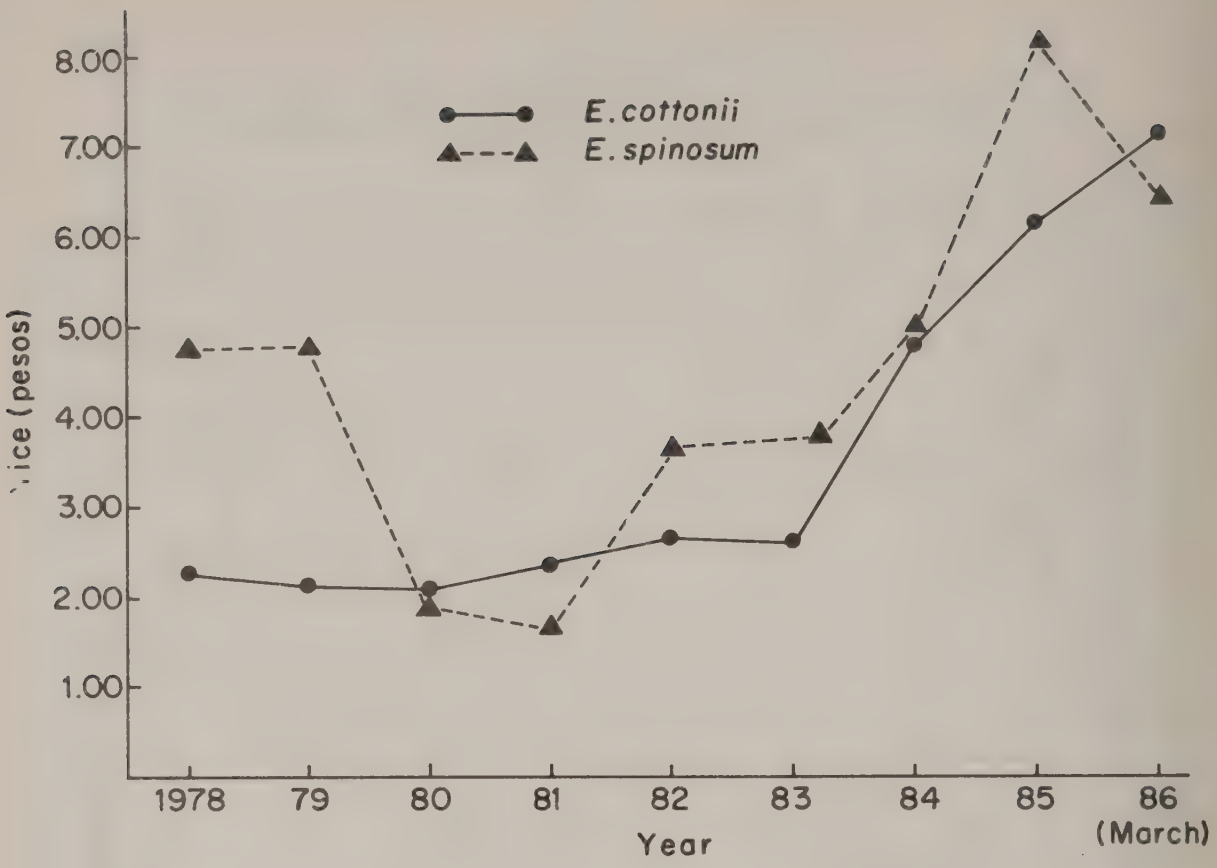

Figure 2 Average prices paid for *E. cottonii* and *E. spinosum* delivered to processors/exporters in Cebu, Central Visayas, 1978-86 (prices not adjusted for inflation, see text)

The steep rise in prices since 1983 is due entirely to inflationary pressures in the Philippines which began with the nation's economic and political crisis in mid-1983. After adjusting for inflation using the Tawi-Tawi cost of living index (1978 = 100; 1985 = 300.2), *E. cottonii* and *E. spinosum* prices in 1985 were actually 15% and 51% lower in real terms than the 1978-79 average (Table 12). These inflationary pressures are also present on the cost side as indicated by the following comparison of prices of selected inputs based on quotations obtained in Cebu City (see Page 16).

Given the lack of any recent survey of seaweed farms in Tawi-Tawi, it is not possible to state categorically whether *Eucheuma* farming is any more or less profitable (in absolute terms) now than it was in the late 1970s. One ongoing study (Santillan, 1986) indicates that the role of middlemen seaweed traders, who often double as suppliers of credit and other seaweed production inputs, has been consolidated in recent years. This study indicates very high real costs of credit to seaweed farmers, much of the borrowing "repaid" through required foodstuff purchases at the shops also owned by the same traders. This "suki" system is well-entrenched throughout the country. The cost of living in Tawi-Tawi has always been high and given the fact that, in real terms, prices received by farmers have actually declined (giving rise to increasing prevalence of farmer seaweed far exceeding the maximum 35-40% moisture content preferred by the Cebu processors/exporters), it seems most likely that seaweed farmers in the Philippines are actually worse off now than they were ten years ago. But this is true of all agricultural and fishing groups in the country, indeed of most wage earners too (average per caput income has declined by 15% in real terms in the last 30 months). *Eucheuma* seaweed farmers as a group are probably still deriving more income from farming than they would from fishing. It is just that the same levels of financial profits and incomes earned as before do not go as far now.

Table 12

Prices of *Eucheuma* and selected farm inputs, adjusted for Southern Mindanao cost of living index

(in pesos)

	1978	1985		Percent increase (decrease)	
	Nominal price/kg	Nominal price/kg	Real price/kg	Nominal price	Real price
E. cottonii	2.13	6.35	1.81	+199%	-15%
E. spinosum	4.73	8.11	2.31	+ 72%	-51%
Southern Mindanao Cost of living Index (COLI)	100		350.2 (all items)[a/]	+250%	

a/ COLI for June, 1985

	1979	1986 (March)	Percent increase	
	(Nominal price)	(Nominal price)	Nominal	Adjusted (Real price)
Monoline (P/kg)	35	80	+129%	-34%
Motorized banca w/ 16 hp engine	5 000	24 000	+380%	+37%
Mangrove stakes (P/piece)	0.25	0.75	+200%	-14%
Gasoline (P/litre)	3.25	6.35	+ 95%	-44%

Table 13

Initial capital cost estimate and annual depreciation (1978 in Indonesian Rupiah) for a one-hectare *E. spinosum* farm in Aru Islands, using floating raft method (800 rafts each 2.5 m x 5 m)

Items required	Cost (Rp)	Useful life (years)	Annual depreciation
Nylon monofilament	460 800	4	115 200
Bamboo	200 000	1	200 000
Wood for rafts	160 000	1	160 000
Wood for poles	120 000	1	120 000
Polypropylene rope	288 000	2	144 000
Polypropylene trying material	60 000	.5	120 000
Rope rings	30 000	2	15 000
Labour (raft construction)	80 000	n.a.	n.a.
Totals	1 398 800		874 200

Source: Adapted from Mubarak (1980). In 1978, Rp 625 = US$ 1.00

This paper has been dwelling extensively upon Philippine *Eucheuma* farming rather than giving equal space to the systems in Indonesia and Malaysia, because little economic data are available on these two. Indeed, the Philippines still enjoys a virtual monopoly on cultured *Eucheuma* which is of higher quality than the wild-gathered type. Malaysian *Eucheuma* farming to date has been essentially experimental only. Indonesian farming moved beyond the experimental stage in the late 1970s, but the first commercial endeavour in the Aru Islands in far eastern Indonesia failed due to bad management of the cooperative established to coordinate marketing (Hollenbeck, 1982).

In the past there have been only two major wild seaweed producing areas in Indonesia: reefs off the coast of South Sulawesi and the province of the Moluccas. Both the regions are far from ready markets and currently there are only two major buyers of Indonesian *Eucheuma* (Hollenbeck, 1982). Recently, one of these corporate buyers has been culturing *Eucheuma cottonii* in the vicinity of Bali using submerged rafts; other experiments have been conducted in nearby Lomboc. Both islands are close to Java and thus offer potential of lower marketing costs for dried seaweeds than do Sulawesi and the Mollucas.

The production and income data from these Bali farms are preliminary only. Bailey *et al.* (1985), based on data provided by the corporate producer, reported that yields of 400 kg/ha (dried weight) per month were being obtained. This translates to almost 5 t/ha/yr^{-1} dried weight or 20-25 t/ha/yr^{-1} wet weight, considerably lower than experimental yields in the Philippines though comparable to the average yields reported for actual Philippine farm conditions. In 1982, Hollenbeck considered this Bali farm still to be experimental saying production costs were still too high. At the time of the Bailey report, Indonesian price per kilogramme paid to the farmer was Rp 250/kg, or approximately US$ 0.21. At the same time in the Philippines, the price being paid was approximately P 6.35 or US$ 0.35. Presumably the difference reflects different marketing costs of the buyer, and perhaps some quality differences though this is purely speculation.

It would appear, however, that Indonesian production costs had fallen since the comment of Hollenbeck three years earlier; indeed, it is now reported that the 100 ha of corporate and family farms in the Bali site are producing 500 t/yr of dried *Eucheuma* (CRIFI, 1985), thus emerging as a potential competitor for Philippine growers. For the healthy development of this Indonesian export market, a steady supply of high quality seaweed will be needed (Mubarak, 1980); the Indonesian production is currently being exported to Europe.

Unfortunately, the Indonesian literature contains not a single complete cost and earnings report for *Eucheuma* farms, experimental or otherwise. This is regrettable because the raft method used there would make an interesting comparison with the Philippine monoline method. A paper by Mubarak (1980) includes only initial investment data and calculation of depreciation (see Table 12), while a document (Murdoch *et al.*, 1977) that refers to *Eucheuma* seaweed culture projects of the Indonesian Marine Fisheries Research Institute at Pulau Telang in the Bintan group of islands between Singapore and Kalimantan or Borneo provides no cost information at all; nor does a report on experimental culture in Seribu (Atmadja and Sulistijo, 1980).

From the Mubarak data (Table 13) it appears that the initial capital requirements for a one hectare *E. spinosum* farm at that time (1978) was approximately US$ 2 250, not including guardhouses or boats. This is considerably more costly than the investment required for an intensively farmed monoline seaweed farm in the Philippines a year later (see Table 7) where initial investment costs (less farm house and boat) were only P 4 880 or US$ 667. While these intercountry cost comparisons are not entirely relevant, the Indonesian seaweed production data reported by Bailey *et al.* (1985) (5 t/ha/yr^{-1}) would imply that not only is the monoline method more productive, it is more economical also. This conclusion is relevant in that Indonesia hopes to compete effectively with the Philippines for the market for cultured *Eucheuma*. Since both countries face the same oligopsonistic market structure, and even the same major buyers, these cost differences will be a major determinant of success. For the moment, Philippine producers are likely to retain their prominent position, especially now that the country's political situation has become somewhat more stabilized, at least for the near term.

3.2 *Gracilaria* culture

As was the case with *Eucheuma*, culture of *Gracilaria* became more attractive and profitable after over-harvesting of wild stocks. While used as human food, the primary importance of *Gracilaria* is for its product agar. Its culture is most advanced in Taiwan, where it began almost twenty five years ago (Shang, 1976). Several species are cultured, the most important of which is *G. confervoides*. This species has also been cultivated in the Central Philippines and was earlier widely available from the wild, including Manila Bay (Sulit, Salcedo and Panganiban, 1956). Indonesia is growing *Gracilaria* in ponds in Sambawa and marketing to Japan (Hollenbeck, personal communication) and is experimenting with the off-bottom and raft methods too (CRIFI, 1985). Its potential in Thailand has been discussed (Edwards and Tam, 1984), though no culture is yet underway. As elsewhere, the Thai interest in *Gracilaria* culture derives from its overharvested wild stock and the valuable foreign exchange that must be spent on imports of agar. Raft culture of *G. verrucosa* and *G. sjoestedtii* have been experimented with in northern provinces of China, alternating seasonally with *Laminaria*. In southern China, a total of 2 000 t (dry weight) of *Gracilaria confervoides* is produced annually through culture on 1 500 ha (Liu Sijian, Zhanjiang Fisheries College, personal communication). This yield is very low compared to Taiwenese yields. In Viet Nam, *Gracilaria* culture began in Haiphong ponds in the 1970s (Ho, 1981).

Despite all this apparent interest, no up-to-date economic information is available on cultured *Gracilaria*. Two studies have been conducted in Taiwan, Province of China (Shang, 1976; Chueh and Chen, 1982) and report financial details for 1975 and 1977 respectively. It is almost an embarrassment to have to proceed here with such outdated information, supplemented by only one brief commentary (Hollings, 1985) which reports Taiwanese production of cultured *Gracilaria* to be 1 100 t in 1980 (most certainly an underestimate).

Shang (1976) estimated annual per hectare production to be 10 t; Chueh and Chen (1982) raised this estimate to 13 t; Hollings (1985) reports New Zealand experimental yields of 40 t dried seaweed/ha/yr^{-1}, but does not specify for which species this yield was obtained, nor whether it was from ponds as in Taiwan, Province of China.

Gracilaria culture in Taiwan, Province of China, is undertaken in the southern part of the island. Beginning with only 100 ha in 1971, area under production increased to over 400 ha by 1977, involving about 200 households. It is worth pointing out here that in land-short Taiwan, Province of China, a 2 ha farm for any farming activity is considered big and certainly above average. *Gracilaria* was produced in monoculture systems and polyculture systems with crabs and shrimps; both systems were financially attractive in 1975 and 1977 (Tables 14 and 15). *Gracilaria* pond culture is essentially a "fattening" operation, the initial pond seeding requiring 5 t per hectare in order to raise 13 t; a net increase of only 8 t/ha/yr^{-1}, according to Chueh and Chen. Except for input costs, production and production value, the Chueh and Chen estimates have apparently been based upon Shang's earlier estimates. Neither estimates appear to be based upon in-depth comprehensive surveys of actual farms. Both show a reasonably labour-intensive operation, with labour costs absorbing approximately 50% of total annual costs. Shang reported an initial capital cost, excluding seed, of US$ 2 441 (NT$ 92 758).

Gracilaria can also be grown in polyculture systems with shrimps and crabs. In 1975 and 1977, this system produced a high rate of return than for monoculture of *Gracilaria*.

As in the monoculture case, the differences in the two estimates can be traced primarily to different estimates of input cost, production and production value. The only difference in input quantities reported by the two is that for number of shrimp juveniles stocked. The net income figures are substantially different, yet each results in an extremely high rate of return on initial capital investment. Shang reports that *Gracilaria* culture in the mid 1970s was viewed by producers as being much more profitable than milkfish culture, the traditional product raised in Taiwanese brackishwater ponds. During the past ten years, milkfish culture has indeed declined in importance and other cultured species, including *Gracilaria* have become more popular (Smith and Chong, 1984; TFB, 1973-82). During the period 1973 to 1982, total production of cultured *Gracilaria* in Taiwan, Province of China, increased from 5 060 t to 9 698 t (TFB, 1973-82). Total value went from NT$ 10 557 000 to NT$ 366 104 000, a unit value/ton increase from NT$ 2 086

(US$ 55) to NT$ 37 750 (US$ 993). Given the pond area actually reported in Taiwanese statistics, it seems reasonable to conclude that the bulk of this production, perhaps as much as 2/3, is gathered from the wild. Either that, or the area statistics are under-reported or the yield/hectare estimates of Shang, Chueh and Chen are much lower than what is currently achieved.

Area under production of *Gracilaria* increased from 112 ha in 1973 (of which 49% were brackishwater ponds) to 242.6 ha in 1982 (of which 93% were brackishwater ponds). In 1973, 64% of the area had been used for monoculture of *Gracilaria*; by 1982, all the brackishwater pond area was devoted to polyculture, reflecting the apparent profitability of these systems as earlier claimed by Chueh and Chen (1982). The interim statistics between these years also indicate a mid-1970s increase in shallow sea culture of *Gracilaria* (139 ha in 1975), but this has since dropped off, perhaps in response to the increased competition for use of this nearshore area. The 1982 statistics indicate only 16 ha being used for this purpose.

In general, it appears that the successful Chinese experiences with monoculture and polyculture of *Gracilaria* in brackishwater ponds has yet to spread to the rest of Southeast Asia.

3.3 *Porphyra* culture

Porphyra is grown only in the most northern parts of the South China Sea region, that is in Southern China and Taiwan, Province of China. Most countries in the region, including Taiwan, Province of China, actually import *Porphyra* for domestic use. *Porphyra yezoensis* and *P. haitanensis* are being extensively cultivated using synthetic netting in Fujian and Guangdong Provinces. Harvest for 1983 was 9 987 t (Chua, in preparation), but no economic analysis is yet available. In 1979, *Porphyra* culture was still very limited in Taiwan, Province of China, confined to Penghu Prefecture off the southwest coast and in Taitung Prefecture in the southeast (Chueh and Chen, 1982). The first *Porphyra* culture began here in the mid 1970s only.

Hanging net culture methods were used with period harvesting being done during the winter months. Because the net is located in the nearshore area, *Porphyra* is susceptible to damage and loss during bad weather. Chueh and Chen (1982) report 1977 investment costs and annual returns for a single production unit (5 frames each 1.5 x 6 m) and for a hypothetical hectare (50 production units). These financial estimates are shown in Tables 16 and 17. *Porphyra* culture yielded a higher net income than *Gracilaria*, yet a lower profit per unit of operating cost, the *Gracilaria* operating costs being only one-third of that required for *Porphyra*.

No more recent financial analysis appears in the *Porphyra* literature, though Taiwanese statistics show an increase in total production over the period 19-- to 19-- from ---- tons to ---- tons.

3.4 *Caulerpa* culture

In certain parts of the Philippines, such as Lingayen Gulf in Luzon and Mactan Island near Cebu City, edible *Caulerpa* is farmed in brackishwater ponds for export to Japan (Calumpong, 1984). Horstmann (1978) and Sotto (1978) have documented this culture, yet financial details remain sketchy. Trono (1981) reports about one dozen pond owners engaging in *Caulerpa* farming in Mactan Island and laments the lack of any financial appraisal, saying that this stands in the way of promoting what appears to be a successful business with good potential for growth.

Most *Caulerpa* in the country is still gathered from the wild, as it is elsewhere in Asia, and is eaten raw (sometimes lightly marinated) as a salad or appetizer item. Calumpong warns of potential overharvesting from the wild as prices rise due to increased demand.

No details on *Caulerpa* culture in other parts of Southeast Asia is available in the literature.

Table 14

Costs and returns (NT$ of *Gracilaria* monoculture) (per hectare): 1975 and 1977

	1975[a] (NT$)	1977[b] (NT$)
Costs		
Labour		
Seeding (2 days)	190	400
Seeding (30 days)	2 850	6 000
Harvesting/drying (100 days)	10 450	20 000
Management (6 months)	14 250	24 000
Subtotal	27 740	50 400
Other operating costs		
Seed stock (5 000 kg)	9 500	15 000
Fertilizer (4 000 kg)	3 800	6 000
Tax and maintenance	4 750	20 000
Subtotal	18 050	41 000
Fixed costs		
Depreciation	5 092	10 000
Lease	1 505	c/
Subtotal	6 597	10 000
Total costs	52 387	101 400
Revenue (10 tons at NT$ 10.45/kg)	104 500	182 000 (13 tons at NT$ 14/kg)
Net income	52 113	80 600
Rate of return on initial investment	56%	d/
Net income per unit of total cost	0.99	0.79

a/ Shang (1976)
b/ Chueh and Chen (1982)
c/ Included in tax figure above
d/ Chueh and Chen did not report an estimate of initial investment

In both 1975 and 1977, NT$ 38 = US$ 1.00

4. CONCLUSION

According to the ADB/FAO study (1983) world production in 1980 of seaweeds for use in the manufacture of colloids, Asia provides 50% of those used for agar, 46% of those used for carrageenan and furcellaran and 40% of those used for alginates. Northeast Asia (Japan and Korea) and China are the world's largest seaweed producers, but Southeast Asia is the world's largest producer of tropical seaweeds. The seaweed colloid industry continues to expand with increased global demand and the processing component of the industry that produces agars and carrageenans has been shifting its base of operations toward Southeast Asia's supply of high quality cultured seaweed has been produced and costs of shipping dried seaweeds to European and North American markets have increased.

Table 15

Costs and returns (NT$) of *Gracilaria* polyculture with shrimps (*Penaeus monodon*) and crabs (*Scylla serrata*)

		1975[a] (NT$)	1977[b] (NT$)	
Costs				
Operating costs				
Gracilaria				
Labour		12 540	26 000	
Seed stock	(4 000 kg)	7 600	12 000	(4 000 kg)
Fertilizer	(4 000 kg)	3 800	6 000	
Subtotal:		23 940	44 000	
P. monodon (shrimp)				
Seed stock	(40 000 fry)	57 000	100 000	(20 000 fry)
Feed		13 300	40 000	
		3 800	8 000	
Subtotal		74 100	148 000	
S. serrata (crab)				
Seed stock	(10 000 fry)	38 000	100 000	(10 000 fry)
Feed		47 500	50 000	
Labour		1 900	5 000	
Subtotal		87 400	155 000	
Other operating costs				
Management		28 500	48 000	
Tax and maintenance		9 500	d/	
Total operating costs		223 440	395 000	
Fixed costs				
Depreciation		5 092	20 000	
Lease		1 634	30 000	
Total		6 726	50 000	
Total costs		230 166	445 000	
Revenues				
Gracilaria	(9 tons)	94 050	126 000	(9 tons)
P. monodon (shrimp)	(4.8 tons[c])	91 200	300 000	(1 ton)
S. serrata (crabs)	(1.5 tons[c])	135 394	255 000	(1.5 tons)
		320 644	681 000	
Net income		90 478	236 000	
Rate of return on initial investment		98%	e/	
Net income per unit of total cost		0.39	0.53	

a/ Adapted from Shang (1976)
b/ From Chueh and Chen (1982)
c/ Shang assumed 60% survival
d/ Included in lease figure below
e/ Chueh and Chen did not report an estimate of initial investment

Table 16

Initial expenditure (NT$) required for *Porphyra* raft cultivation in Taiwan, Province of China, for one production unit (5 rafts each 1.5 x 6 m) in 1977

Item	Quantity	Price (NT$)	Expenses (NT$)	Years of Service	Annual cost (NT$)
Nets	10	350	3 500	2	1 750
Plastic bags	180	1	180	1	180
Bamboo poles (short)	25	30	750	2	375
Bamboo poles (long)	10	40	400	2	200
Oyster shells	1 200	0.18	220	1	220
String			500	2	250
Anchors	2	900	1 800	6	300
Construction labour	2 days	250	500	2	250
Power raft	1/10[a/]	20 000	2 000	5	400
Total			9 850		3 925

a/ See Table 17

Source: Chueh and Chen (1982)

Table 17

Annual costs and earnings (NT$) for *Porphyra* raft culture in Taiwan, Province of China, in 1977

Item	Price (NT$)	Production unit		Hectare	
		Quantity	Value (NT$)	Quantity	Value (NT$)
Production value *Porphyra*	140	55 kg	7 700	2 750 kg	385 000
Production cost					
Conchocelis-bearing[a/] oyster shells			400		20 000
Cost of capital goods[a/]			3 925		196 250
Labour cost of planting and harvesting	250	3 days	750		37 500
Misc. (gasoline for motor boats, etc.)			345		17 250
Labour cost of management	4 000		480	6 months	24 000
Total			5 900		295 000
Net Income			1 800		90 000

a/ Derived from Table 16

Source: Chueh and Chen (1982)

Seaweed culture in the South China Sea region has developed through the efforts of small farms of a hectare or less, most often family-run. While it is apparent that these farms are still producing less on a per hectare basis than corporate and experimental farms show is possible, there is much to be pleased with in terms of private sector initiative in developments of small-scale seaweed farming.

An in-depth economic analysis has not yet been conducted on any of the Southeast Asian culture systems for *Eucheuma, Gracilaria, Porphyra* and *Caulerpa*. Such an analysis would be very timely to address the key issues facing small-scale farms, their performance since they began and likely role as these industries continue to expand which with political stability they undoubtedly will. Based on the inadequate data collected to date from experimental units and from short interviews of a small number of perhaps unrepresentative producers, it appears that high rates of return and quite high monthly incomes (relative to the alternatives, often few) can be earned from seaweed farming. An in-depth economic analysis could help bring a note of realism to projections of likely annual yields from new areas.

For many small farms, facing capital and labour shortages (capital is needed to hire labour no matter how low the wage paid) and not shortages of reef area to farm, it makes more sense to maximize production per unit of capital or labour rather than to maximize yield per hectare. This point is often lost on aquaculturists who insist on comparing yields/hectare in regions with extreme land and labour shortages (e.g., Taiwan, Province of China) with yields/hectare in countries with extreme capital shortages (e.g., Philippines). Differences in yields/hectare make economic sense under such disparate conditions.

When the cost of borrowing money approaches 50% per year, as it has in the past two years from development banks in the Philippines (and would be even more costly from private money lenders) and seaweed price increases have not kept pace, one would expect that family farms would limit their productive effort to the own-capital means available to them. Given the initial capital investment and first year operating capital required for a *Eucheuma* farm, for example, most families would tend to start on a modest scale, then expand. Seaweed farming lends itself to such an approach as numerous authors have pointed out. Since income must still be foregone, however, seaweed farming also lends itself to a part-time family activity. Yet, to date, none of the above issues have been adequately addressed by researchers, who have tended to focus on technical and environmental details.

How do individual farmers respond to initial success? No-one knows for sure. How do farmers perceive the ologsonistic corporate market structure, and the combined money-lender/middlemen/storekeeper economic power they must deal with on a daily basis? Observations have been made on these issues in fishing communities, but does seaweed farming offer a means of achieving financial independence? Is this socially acceptable in communities that engage in seaweed farming? No-one knows for sure.

There is always the temptation to generalize about small-scale seaweed farming and given space limitations, this paper has not adequately pointed to the key differences that must exist between reef seaweed culturists (who are most likely former full-time fishermen with few alternatives) and pond seaweed culturists (who most likely are simply seeking a means of increasing their returns from an existing culture facility). What, however, are the different perceptions of such individuals to risk and uncertainty? These perceptions may have a great bearing over how intensively the farmer may choose to farm the seaweed area available to him. A farm close to home may be preferred over an environmentally better suited farm at a further location, for example, if the risk of poaching or losing one's life at sea in an unexpected typhoon are major considerations.

In short, there are many factors that may influence the relative success of seaweed farmers and their farms. Not only are the various costs-and-earnings studies reported in this paper very out-of-date, but no economic investigations have so far addressed the key questions of variability in yields and profits amongst seaweed farms and within individual farms from year to year. Until these questions are posed and answered, the future role of small farms in the developing seaweed industries of the South China Sea region will continue to be a matter of conjecture.

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